Quick introduction on the Forex trading for Automated trading system

Mathieu Guillame-Bert
INRIA Rhône-Alpes Research Center
mathieu.guillame-bert@inria.fr

This document is an introduction on Forex trading for Automated trading systems. This document is part of the Forex Dataset – Automated Trading Experiment available at http://www-prima.inrialpes.fr/guillame-bert/. This document is also an extract of my thesis.

1 Stock exchange markets

A *stock exchange market* is a market used by *traders* to exchange products such as shares, bonds, warrant, index fund, currencies, oil, etc. In these markets, the selling/buying prices (also called ask/bid prices) are automatically calculated according to the supply and demand (the buying price is always higher than the selling price). The difference between the buying price and the selling price is called the *spread*. Since the value of goods are constantly changing, the goal of the brokers is to buy products at low price, and resale them later at higher price. The work of a trader is to forecast the evolution of the product prices.

Traders are either professional workers in financial institutions or individual investors. Professional traders invest their company money, while individual investors use their own resources. Trader's predictions are based on market observation, market knowledge and the world news.

A large panel of theories and tools has been developed to assist the traders. Two families of tools can be distinguished: (a) The *information systems* that produce more or less complex signals and alerts interpretable by the traders and (b) The *automated or robotic traders* that directly send buy/sell orders.

Tools from these both families need precise parameter tuning. Therefore, event in the case of automated trading, a human trader should still be in present to adjust the parameter of the automated trader.

2 Forex

The Foreign exchange market (Forex) is a type of stock exchange market where traders trade currencies (e.g. US Dollars, Euros, Yen, etc.).

This market is the largest market in the world in term of money transaction (approximately $4 trillion is exchanged every day). The market is open all week, it has a high liquidity (the difference between selling and buying price is

small), and it has not fixed cost by order. This market is especially sensitive to employment reports, economic forecasts, economic reading and banks activities.

Since currencies are bond to countries (or groups of countries), values of a currencies are correlated to countries' stability, the countries' resources, and the countries' interest rate. The fluctuation of exchange rate between currencies depends on the value of each currency individually. These fluctuations are generally small, and traders need to use the *leverage*.

The *leverage* is the operation to borrow a large amount of money, to invest it in a pair of currency, resale the pair, and reimburse the 'loan'. This operation allows traders with small amount of money to make reasonable benefit. The leverage increase the benefit but it also increase the looses. The Forex operators (brokers) are asking a guaranty for the loan (the loan is between $50\times$ and $400\times$). If the lost of an order exceed the guarantee, the broker close the order, take back the loan, and the trader loose the guaranty. This description is not perfectly accurate but it gives a good idea of what is the leverage.

The next example shows a detailed Forex buying transaction.

Example 2.1 *Consider the ask (asking price) of the EURUSD to be 1.33075 (i.e. 1 Euro gives 1.33075 Dollars). A trader predicts that the EURUSD will increase, therefore he buys 100 000€ for \$133 075. With a leverage of* $100\times$*, the trader has to give a guarantee of \$1 330.75. Thirty minutes later, the bid of the EURUSD is 1.33198. The trader sell its 100 000 € for \$133 198. He reimburses the \$133 075 loan. At the end of the operation, the trader has win \$111 = \$133 198 - \$133 075.*

The fig. 1 shows an example of selling transaction.

Forex exchange rates are updated in real time (up to the micro second for (automated) high frequency trading). In order to be used by humans, the exchange rates are discretized (usual discretization periods are 1mn, 5mn, 15mn, 30mn, 1h and 4h). Most traders are using 30mn or 1h periods. The orders of human traders have generally duration of a couple of hours.

Traders use *indicators* (or indexes) to understand the situation of the market (SMA, MACD, etc.). Basic indicators are presented in the next section. Trader can also be assisted by *Information Systems*. Such systems give indications and alerts on the probable evolution of the exchange rates.

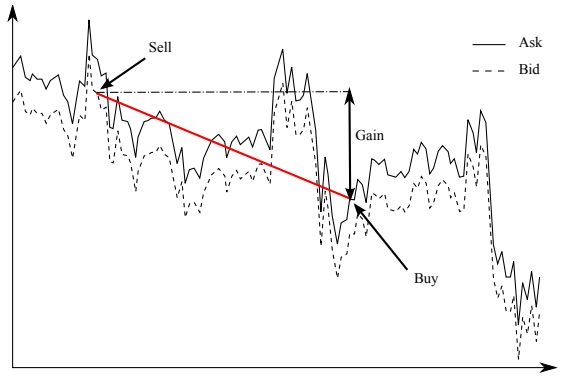

Figure 1: Example of Forex transaction with positive profit

On the other hand, fully automated trade systems are computer programs that send buying and selling orders automatically. Such programs are generally base on production rules such as:

```
Buy - When the 30-day moving average (MA) crosses above the 60-day MA
Sell - When the 30-day MA crosses below the 60-day MA
Stop - Maximum loss of 10 units
Target - Target of 10 units
```

The work of the trader is to configure the parameters of the program. Automated trade systems are wildly used, especially by Large financial institutions (in 2006, 25% of Forex orders where generated by fully automated trade systems). The fact that a trader is using an automated trade system is generally known, but the rules used by the system are kept secret.

High-frequency trading is a special kind of trading made by automated traders. This kind of trading is very fast (orders can be as short as 10 milliseconds) and produces a large amount of order (millions of simultaneous orders). Such trading system tries to spot increases or decreases of rate before the other actors of the market.

Because of the high update frequency (large dataset), direct outcomes, and complexity of the problem, the Forex is one of the great challenges of the machine learning. A large amount of techniques have been applied to the Forex trading to produce Information Systems and Fully automated traders (Neural network (Gan and Ng, 1995; Yao and Tan, 2000), Support vector machines (Cao and Tay, 2001; Kamruzzaman *et al.*, 2003), Evolutionary algorithms (Myszkowski and Bicz, 2010; Dittmar *et al.*, 1996; Connor and Madden, 2006), etc.). The paper (Atsalakis and Valavanis, 2009) is a summary and analysis of more than one hundred articles dealing with Forex forecasting with Neural Networks.

3 Indicators and trends

This dataset is a record of three years of the EURUSD exchange rate sampled approximately every minute (from June 5 2008 to June 5 2011). From the dataset, we extract 'trends' (see definition below). We are also computing three basic indicators (MACD(12,26,9), SMMA(14) and Awesome – see definition below) with a 30 minute window size. The signals of the indicators are discretized with two types of states (X-is-greater-than-Y and X-is-lower-than-Y) and two types of events (X-becomes-greater-than-Y and X-becomes-lower-than-Y), where X is an indicator and Y is a fixed value. Next, the record is split into three 1 year long parts. The first part of the dataset is used for the learning (June 5 2008 – June 5 2009), the second part is used for the over training evaluation (June 5 2009 – June 5 2010), and the last part is used for the evaluation (June 5 2010 – June 5 2011). We use the Titarl algorithm to learn and predict the future trends according to the discretized signals.

Definition 3.1 *A* Moving Average *(MA) is a* finite impulse response filter *(i.e. the response is computed from a finite set of sample) used to smooth out small fluctuations. It is computed as an average of the last N values of a signal (or from N values sampled with a window size in the case of continuous signal). By convention, MA(N) is a moving average based on the last N values.*

The Simple Moving Average *(SMA) is a moving average where the last N values have the same weight. If v_i represent the i^{th} value. The SMA at time i is $SMA_i = \frac{v_i+v_{i-1}+v_{i-2}+\cdots+v_{i-(N-1)}}{N}$. The fig. 2 gives an example of SMA.*

With the same convention, the Exponential Moving Average *(EMA) is defined as $EMA_0 = v_0$ and $EMA_i = \alpha v_i + (1-\alpha)EMA_{i-1}$ with $\alpha = \frac{2}{N+1}$.*

The SMoothed Moving Average *(SMMA) is an EMA with different at initialisation. Additional, the N parameter of the SMMA (written N_{SMMA}) is defined as $N_{SMMA} = \frac{N_{EMA}+1}{2}$ with N_{EMA} the N parameter of the EMA.*

Definition 3.2 *A* Moving Average Convergence Divergence (MACD(X,Y,Z)) *index is composed of two output signals. The first one is the difference between an EMA(X) and an EMA(Y) of the exchange rate. The second one is a EMA(Z) of the first output signal.*

Definition 3.3 *The* Awesome *index is the difference between a SMA(5) and a SMA(34). These SMAs are computed of the 'middle points' of the exchange rate. Given a signal and a window, the* middle point *is the average of the higher value and the lower value of the signal in this window.*

Definition 3.4 *A* trend *is a tendency of the exchange rate to increase (upward trend) or decrease (downward trend) from a time scale (from decades to minutes).*

In this work, trends are defined by four parameters: A direction (upward or downward), a beginning, a duration and a gradient.

There is an upward trend between times t_1 and t_2 (the duration of the trend is $t_2 - t_1$), if the value $v(t)$ of signal a time $t \in [t_1, t_2]$ is always greater than $v(t_1) + (v(t_2) - v(t_1))\frac{t-t_1}{t_2-t_1}$.

Symmetrically, there is a downward trend between times t_1 and t_2 if the value $v(t)$ of signal a time $t \in [t_1, t_2]$ is always lower than $v(t_1) + (v(t_2) - v(t_1))\frac{t-t_1}{t_2-t_1}$.

In this experiment, the duration and gradient of the trends are limited to pre-defined sets of values. Several trends can occur simultaneously, but we avoid having overlapping trends with similar durations and gradients.

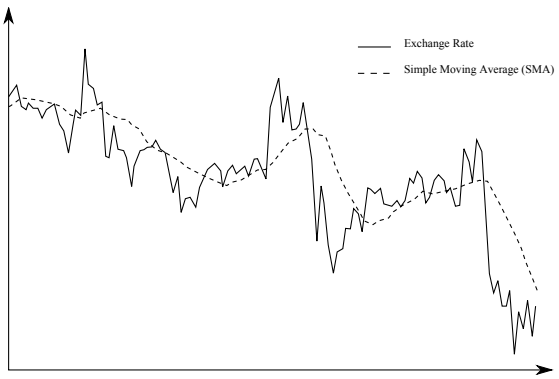

Figure 2: An example of signal, and the simple moving average (SMA) on this signal.

We use a greedy algorithm to extract trends from the exchange rate signal. For every possible durations and gradients, we associate a symbol e.g. 'start_upward_trend_grad_is_X_duration_is_Y'. The fig. 3 gives an example of upward and downward trends.

The fig. 4 shows 24 hours of signal, indicators and discretized events.

References

Atsalakis, G.S. and Valavanis, K.P. "Surveying stock market forecasting techniques - part ii: Soft computing methods". In *Expert Syst. Appl.*, 36(3):5932–5941 (2009). ISSN 0957-4174. doi:10.1016/j.eswa.2008.07.006.

Cao, L. and Tay, F.E. "Financial forecasting using support vector machines". In *Neural Computing Applications*, 10:184–192 (2001). ISSN 0941-0643. 10.1007/s005210170010.

Connor, N.O. and Madden, M.G. "A neural network approach to predicting stock exchange movements using external factors". In *Knowledge-Based Systems*, 19(5):371 – 378 (2006). ISSN 0950-7051. doi:10.1016/j.knosys.2005.11.015. ¡ce:title¿AI 2005 SI¡/ce:title¿.

Dittmar, R., Neely, C.J. and Weller, P. "Is technical analysis in the foreign exchange market profitable? a genetic programming approach". CEPR Discussion Papers 1480, C.E.P.R. Discussion Papers (1996).

Gan, W.S. and Ng, K.H. "Multivariate forex forecasting using artificial neural networks". In "Neural Networks, 1995. Proceedings., IEEE International Conference on", volume 2, pages 1018 –1022 vol.2 (1995). doi:10.1109/ICNN.1995.487560.

Kamruzzaman, J., Sarker, R.A. and Ahmad, I. "Svm based models for predicting foreign currency exchange rates". In *Data Mining, IEEE International Conference on*, 0:557 (2003). doi:http://doi.ieeecomputersociety.org/10.1109/ICDM.2003.1250976.

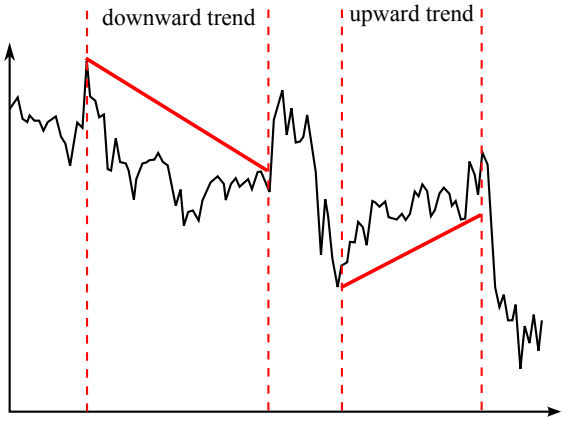

Figure 3: An upward an a downward trends.

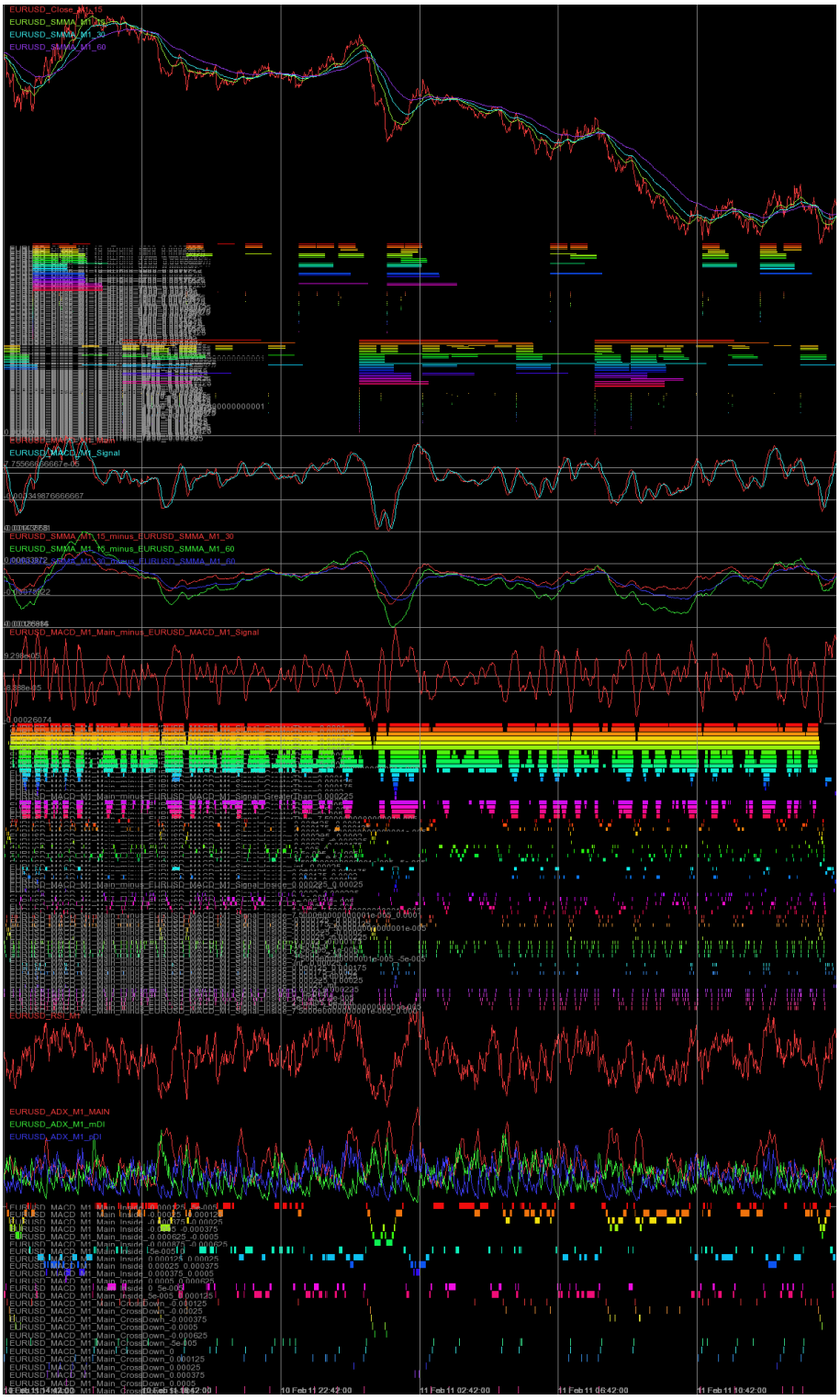

Figure 4: Twenty four hour previous of signal, indicators and discretized events of the EURUSD exchange rate.

Myszkowski, P. and Bicz, A. "Evolutionary algorithm in forex trade strategy generation". In "Computer Science and Information Technology (IMCSIT), Proceedings of the 2010 International Multiconference on", pages 81 –88 (2010). ISSN 2157-5525.

Yao, J. and Tan, C.L. "A case study on using neural networks to perform technical forecasting of forex" (2000).